

A New Cascade Frog of the Subgenus *Odorrana* from Peninsular Malaysia

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We describe a new species of cascade frog of the genus *Rana*, from west Malaysia. *Rana monjerai*, new species is a medium-sized frog of the subgenus *Odorrana* (SVL of males, 38–43 mm; of one female, 75 mm), and is distinguished from all other members of this subgenus by the combination of: white lip stripe, dorsolateral fold, full web on the fourth toe, vomerine teeth, gular vocal pouch and relatively large tympanum in males, no dorsal marking, no clear light spots on rear of thigh, first finger subequal to second, finely tuberculated dorsum, and unpigmented ova. The significance of finding this species from peninsular Malaysia is discussed.

Key words: cryptic species, *Rana*, new species, Southeast Asia, taxonomy, zoogeography

INTRODUCTION

Along mountain streams in subtropical and tropical regions of East to Southeast Asia, there are small to medium-sized, long-legged ranid frogs represented by species like *R. narina* Stejneger, 1901 from the Ryukyu Archipelago of Japan; *R. livida* (Blyth, 1856) from China to Myanmar (now proved to be a composite of allied species, see Bain *et al.*, 2003); and *R. hosii* Boulenger, 1891 from the Malay Peninsula to Borneo (Bourret, 1942; Liu and Hu, 1961; Taylor, 1962; Inger, 1966; Maeda and Matsui, 1989; Fei *et al.*, 1991).

These cascade frogs have been treated variously as a distinct genus, *Odorrana* (Fei *et al.*, 1991), or as subgenera *Eburana*, *Odorrana*, and *Chalcorana* of the genus *Rana* (Dubois, 1992). However, a recent phylogenetic analysis of mtDNA sequences revealed their monophyly within the genus *Rana* (Matsui *et al.*, 2005), and suggested use the subgeneric name *Odorrana*, which precedes other names (Fei *et al.*, 1991).

Through the extensive field surveys in East and Southeast Asia, many species of *Rana* (*Odorrana*) have been described in this decade (Matsui, 1994; Fei *et al.*, 2001a,b; Orlov *et al.*, 2003; Bain and Nguyen, 2004; Stuart and Bain, 2005). Of these, most species from Southeast Asia have been reported from Vietnam and Laos, and no new *Rana* (*Odorrana*) has been reported from western Malaysia. Only *R. hosii* was known from this region (Berry, 1975), although Taylor (1962) included Perak in the range of *R. livida*.

On a recent trip to Gunung (=Mount) Jerai, in the northern part of the western coast of West Malaysia, the junior author collected five specimens of *Rana* (*Odorrana*) super-

ficially resembling *R. hosii*, which the senior author (Matsui, unpublished data) had obtained at higher elevations on the same mountain. Later examination of these specimens, however, revealed that they are clearly different from *R. hosii* in the presence of gular pouches in males. Further study of the specimens by consulting with a recent review of the group (Bain *et al.*, 2003) led us to conclude that they represent a new species, which is described below.

MATERIALS AND METHODS

A field survey was made between 4 and 10 June 2005 along the Teroi River on the northern slopes of Gunung Jerai, on the western coast of West Malaysia. We collected specimens by hand, anesthetized them with chloroform, and fixed them in 10% formalin. For preserved specimens, we took the following 16 body measurements, mainly following Matsui (1984), to the nearest 0.1 mm with dial calipers: snout-vent length (SVL); head length (HL), from tip of snout to hind border of angle of jaw (not measured parallel with the median line); eye length (EL); tympanum diameter (TD); head width (HW); internarial distance (IND); interorbital distance (IOD); upper eyelid width (UEW); lower arm length (LAL); first finger length (1FL), from junction of first and second fingers to tip of first finger; second finger length (2FL), distance from junction of first and second fingers to tip of second finger; third finger disk diameter (3FDW); fourth toe disk diameter (4TDW); hindlimb length (HLL); tibia length (TL); foot length (FL), from proximal end of inner metatarsal tubercle to tip of fourth toe. Character definitions follow Bain *et al.* (2003). For diagnosing the new species, we examined 35 specimens of *R. hosii* from Malay Peninsula, including four from Gunung Jerai (KUHE 15291–15292, 15371–15372; KUHE=Graduate School of Human and Environmental Studies, Kyoto University).

SYSTEMATICS

Rana monjerai sp. nov.
(Fig. 1)

Diagnosis

A medium-sized form of *Odorrana*; female 75 mm, males from 38 to 43 mm in snout-vent length (SVL); distinct

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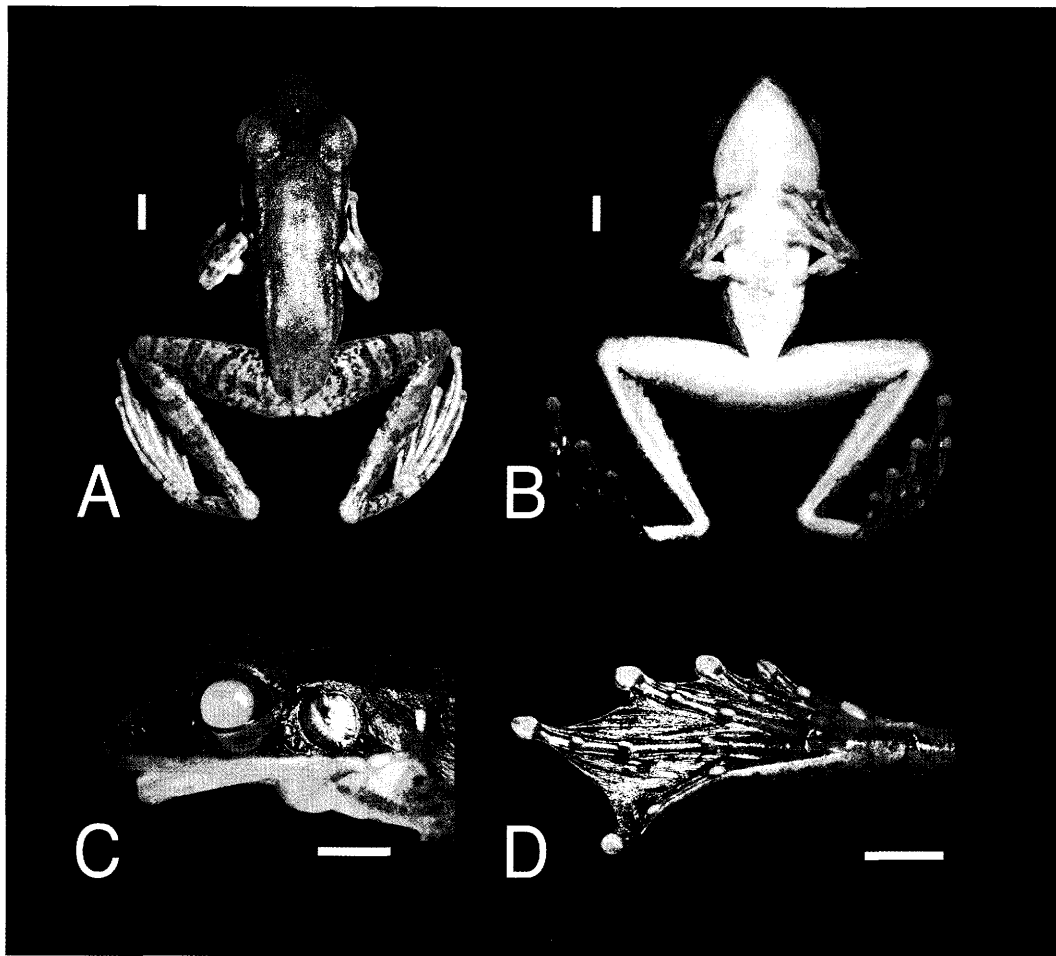


Fig. 1. Male holotype of *Rana monjerai* [USM (Universiti Sains Malaysia) 422, SVL=43.2 mm]: (A) dorsal view; (B) ventral view; (C) profile; (D) ventral view of right foot. Scale bar: 5 mm.

dorsolateral fold present; first finger subequal to second; toe webbing full on the fourth toe; vomerine teeth present; gular vocal pouch present in males; tympanum large in males, 51–66% of eye length, much smaller in female; dorsum finely tuberculated; upper lip broadly striped white; dorsal marking absent; rear of thigh without light spots; ova unpigmented.

Holotype

USM (Universiti Sains Malaysia) 422 (original field number IJJW 070605-2), an adult male from the Terai River on Gunung Jerai, State of Kedah, West Malaysia (5° 47'N, 100° 27'E, alt. 720 m a.s.l.). Collected on 7 June 2005 by I. Jaafar and L.-H. Wong.

Paratypes

USM 423 (Original field number IJJW 070605-3), USM 424 (original field number IJJW 070605-4), USM 426 (original field number IJJW 070605-6), and USM 429 (original field number 070605-9), three adult males and an adult female, same data as for the holotype.

Description of holotype

Body moderately slender; head triangular, longer than wide; snout straight dorsally, rounded at tip, projecting beyond lower jaw, rounded in profile; eye large, longer than

snout; canthus distinct; lore vertical, deeply concave, nostril nearer to tip of snout than to eye; internarial distance much wider than interorbital; latter much narrower than upper eyelid; pineal spot visible, slightly anterior to line connecting anterior corners of orbits; tympanum conspicuous, more than one-half of eye diameter and separated from eye by one-sixth of tympanic diameter; vomerine teeth in short, oblique groups, beginning from anterior to a line connecting anterior corners of choanae and extending posteromedially, groups equidistantly separated from each other and from choanae by about half length of each group; tongue deeply notched, without papilla; paired subgular vocal sacs form gular pouches at corners of throat; vocal openings just inside commissures of jaws.

Forelimb stout; fingers unwebbed; first finger subequal to second; fourth longer than first; tips dilated into disks having circummarginal grooves, the outer two wide, width 2.5 times width of phalanges; disk of third finger slightly less than half diameter of tympanum; distinct nuptial pads, cream in colour and velvety in structure, covering dorsal and median surfaces of the first finger from its base to distal edge of the subarticular tubercle.

Hindlimb rather long, about two times SVL; heels overlapping when limbs are held at right angles to body; tibiotarsal articulation of adpressed limb reaching beyond tip of snout; disks of toes narrower than those of two outer fingers;

third toe shorter than fifth; toes fully webbed, to disc in first to third and fifth toes; fourth toe moderately widely webbed to base of disc on inner and outer edges; webs thick, not crenulate; subarticular tubercles very prominent, oval; inner metatarsal tubercle distinct, oval, one-third length of first toe; outer metatarsal tubercle absent; no tarsal fold.

Dorsum finely granular with glandular dorsolateral folds and flat supratympanic folds; side of trunk coarsely granular; chest and abdomen smooth.

Color in formalin

Dorsum grayish brown without distinct marking; lore with a dark marking below canthus; upper lip broadly banded white, without dark marking; tympanum dark brown, encircled by light brown, with blackish-brown rim; dorsolateral fold edged with dark; flank dark brown; limbs marked dorsally, with dark brown crossbars; rear of thigh indistinctly mottled with dark and light spots; lower lip white without marking; abdomen and ventral surfaces of hindlimb whitish; throat scattered with pigmentation of melanophores along inner side of lower lip and around vocal pouches; foot webbing dark brown.

Measurements of holotype

Measurements (in mm) in preservative: SVL 43.2; HL 17.1; EL 7.4; TD 4.1; HW 14.0; IND 4.8; IOD 3.5; UEW 4.5; LAL 21.5; 1FL 5.8 (right hand) and 5.9 (left hand); 2FL 5.8 (right hand) and 5.6 (left hand); 3FDW 1.9; 4TDW 1.8; HLL 80.4; TL 26.4; FL 23.0.

Variation

A single female (SVL=75.3 mm) is larger than four males (38.4–43.1 mm, mean \pm SD=41.88 \pm 2.32 mm). The small number of samples limited statistical comparisons, but some dimensions relative to SVL seem to be sexually dimorphic. Males have larger values relative to SVL than females in head width (32.0–34.1% vs. 31.9%), head length (38.8–40.4% vs. 37.9%), upper eyelid width (10.2–10.4% vs. 9.3%), eye length (15.8–17.1% vs. 13.6%), and tympanum length (8.4–10.9% vs. 5.3%).

Lengths of eye and snout are subequal in the female. Pineal spot is located slightly posterior to line connecting anterior corners of orbits in one male. Tympanum is separated from eye by one-third and three-fifths of its diameter

in one male and the female, respectively. First finger is slightly longer than second in some specimens but vice versa in others, and in one specimen, the relationship is reversed in the right and left hands. In the female, disk of third finger is four-fifths diameter of tympanum, and vomerine tooth groups are separated from each other and from choanae by about one-third the length of each group. Dorsolateral fold is feeble in two males and is distinct in anterior one-third in the female. One male has weak whitish asperities on lower lip, on dorsolateral fold, and on tibia. Individuals are fairly uniform in coloration and pattern of markings, but upper lip is scattered with pigmentation of melanophores in two males, and flank is posteriorly marked with small dark spots in one male. In the female, dark brown color on flank is restricted to anterior one-fifth. From the photographs taken of three males in life, the dorsal color varies from green with dark brown spots to dark brown with irregular green markings. One male has brownish flecks on throat.

Eggs

Diameter of an ovum from a female is 2.3 mm. The eggs are entirely cream in colour

Comparisons

Rana monjerai superficially resembles *R. hosii*, and both of these species have been collected from Gunung Jerai, although neither simultaneously nor syntopically (see below). A subadult female of *R. hosii* (SVL=69.4 mm) had a dusky venter, unlike *R. monjerai* with white venter. Adult females of *R. hosii* from other localities on the Malay Peninsula had greater SVL (80.2–95.3 mm, mean=85.2 mm, n=6) than *R. monjerai* (75.3 mm), and all had a dusty venter (Matsui, unpublished data). *Rana hosii* is larger than *R. monjerai* also in males (SVL=44.5–53.2 mm, mean=48.0 mm, n=17, and 38.4–43.2 mm, mean=41.9 mm, n=4, respectively). Males of the two species differ from each other more clearly than females, because *R. hosii* lacks the pair of gular pouches that are present in *R. monjerai*. In this regard, *R. monjerai* is more similar to *R. livida* than to *R. hosii*, both of which are assigned to the subgenus *Odorrana* (Matsui *et al.*, 2005). It is not easy to allocate ranine species from Asian regions to *Odorrana*, but some species from China (Fei *et al.* 1991; Fei *et al.*, 2005) and other species defined as the *R. chloronota* complex by Bain *et al.* (2003) and subsequent

Table 1. Measurements of 16 characters in *Rana monjerai*. SVL is given as mean \pm 1SD, in mm); medians of ratios (R) of other characters to SVL (in %) are followed by ranges in parenthesis. See Materials and Methods for character abbreviations.

Sex	n	SVL	RHW	RHL	RLAL	RTL	RFL
Male	4	41.9 \pm 2.32 (38.4–43.2)	33.1 (32.0–34.1)	39.5 (38.8–40.4)	49.8 (49.5–52.6)	65.5 (61.1–66.4)	54.8 (53.2–57.6)
Female	1	75.3	31.9	37.9	49.8	63.5	55.6
Sex	n	RHLL	RIND	RIOD	RUEW	REL	RTD
Male	4	198.0 (186.1–207.3)	10.7 (10.0–11.1)	8.2 (7.0–8.4)	10.3 (10.2–10.4)	16.5 (15.8–17.1)	9.4 (8.4–10.9)
Female	1	192.3	10.1	8.4	9.3	13.6	5.3
Sex	n	R1FL	R2FL	R3FDW	R4TDW		
Male	4	13.1 (11.5–13.5)	13.1 (12.5–13.6)	4.4 (4.2–5.4)	3.6 (3.4–4.2)		
Female	1	14.6	13.1	4.6	3.6		

authors (Orlov *et al.*, 2003; Bain and Nguyen, 2004) are considered to be members of *Odorrana*. Although Stuart and Bain (2005) refrained from placing their new species in *Odorrana*, we tentatively include them in this subgenus.

Rana monjerai differs from other species of the subgenus *Odorrana* in the following characteristics (data from Bain *et al.*, 2003; Bain and Nguyen, 2004; Fei, 1999; Fei *et al.*, 1991, 2005; Inger, 1966; Maeda and Matsui, 1999; Stuart and Bain, 2005; Stuart *et al.*, 2005): (1) Presence in males of a pair of gular pouches [absent in *R. andersonii* Boulenger, 1882; *R. exiliversabilis* Li, Ye, and Fei in Fei, Ye, and Li, 2001; *R. grahami* Boulenger, 1917; *R. hainanensis* (Fei, Ye, and Li, 2001); *R. hmongorum* Bain, Lathrop, Murphy, Orlov, and Ho, 2003; *R. jingdongensis* (Fei, Ye and Li, 2001); *R. junlianensis* (Huang, Fei, and Ye in Fei and Ye, 2001); *R. kuangwuensis* Liu and Hu in Hu, Zhao, and Liu, 1966; *R. margaretae* Liu, 1950; *R. versabilis* Liu and Hu, 1962; *R. wuchuanensis* Xu in Wu, Xu, Dong, Li, and Liu, 1983; and *R. hosii*]. (2) Possession of white lip (lip not white in *R. bacboensis* Bain, Lathrop, Murphy, Orlov, and Ho, 2003; *R. bolavensis* Stuart and Bain, 2005; *R. heatwolei* Stuart and Bain, 2005; *R. lungshengensis* Liu and Hu, 1962; *R. orba* Stuart and Bain, 2005; *R. schmackeri* Boettger, 1892; *R. sinica* Ahl, 1927 "1925"; *R. tiannanensis* Yang and Li, 1980; and *R. trankieni* Orlov, Ngat, and Ho, 2003). (3) Presence of dorsolateral fold [absent in *R. chloronota* (Günther, 1876); *R. hejiangensis* Deng and Yu, 1992; *R. ishikawae* (Stejneger, 1901); *R. livida*; and *R. lungshengensis*. Fold indistinct and interrupted in *R. amamiensis* Matsui, 1994; *R. narina*; *R. supranarina* Matsui, 1994; *R. swinhoana* Boulenger, 1903; and *R. utsunomiyaorum* Matsui, 1994]. (4) Non-enlarged tympanum in male [large tympanum, >0.66 times eye length in *R. banaorum* Bain, Lathrop, Murphy, Orlov, and Ho, 2003; *R. graminea* Boulenger, 1900; *R. megatympanum* Bain, Lathrop, Murphy, Orlov, and Ho, 2003 (including *R. tabaca* Bain and Nguyen, 2004); *R. morafkai* Bain, Lathrop, Murphy, Orlov, and Ho, 2003; and some *R. orba*]. (5) First and second fingers subequal (first finger shorter than second in *R. daorum* Bain, Lathrop, Murphy, Orlov, and Ho, 2003; *R. iriodes* Bain and Nguyen, 2004; and *R. sinica*. Second finger shorter than first in *R. amamiensis*, *R. bacboensis*, *R. banaorum*, *R. bolavensis*, *R. chloronota*, *R. hainanensis*, *R. heatwolei*, *R. hejiangensis*, *R. hmongorum*, *R. junlianensis*, *R. kuangwuensis*, *R. livida*, *R. margaretae*, *R. megatympanum*, *R. morafkai*, *R. narina*, *R. orba*, *R. schmackeri*, *R. supranarina*, *R. swinhoana*, *R. tiannanensis*, and *R. utsunomiyaorum*). (6) Full web on the fourth toe (not full in *R. anlungensis* Liu and Hu in Hu, Zhao, and Liu, 1973; *R. leporipes* Werner, 1930; *R. bolavensis*, *R. daorum*, *R. iriodes*, *R. orba*, *R. supranarina*, and *R. utsunomiyaorum*). (7) Absence of outer metatarsal tubercle (present in *R. nasuta* Li, Ye, and Fei in Fei, Ye, and Li, 2001, and *R. exiliversabilis*; sometimes present in *R. heatwolei*). (8) Absence of "serration" along upper lip (present in *R. exiliversabilis*, *R. nasuta*, and *R. versabilis*). In addition, *Rana leporipes* is reported to have a characteristically white supratympanic fold, which is not seen in *R. monjerai*.

Additionally, several other ranine species superficially resemble the new species, but cannot be assigned with certainty to *Odorrana* in the absence of phylogenetic evidence. Of these, *R. archotaphus* Inger and Chan-Ard, 1997 and *R.*

khalam Stuart, Orlov, and Chan-Ard, 2005 possess an outer metatarsal tubercle, unlike *R. monjerai*. *Rana archotaphus* also differs from *R. monjerai* in lacking a full fourth toe web.

Range

Known only from the type locality, the Teroi River on Gunung Jerai, western coast of West Malaysia.

Natural history

This species was found perching on rocks and sand along mountain streams about 720 m above mean sea level in montane myrtaceous forest (Gregory-Smith, 1994) on Gunung Jerai. The breeding season seems to be later than early June, because a single female collected has fully mature eggs in her ovaries. Associated anuran species observed include *Limnonectes blythi*, *L. laticeps*, and *R. chalconota*. *Rana hosii* has been recorded (Matsui, unpublished data) on Gunung Jerai at localities higher in altitude (1050–1100 m) than the type locality of *R. monjerai*.

Etymology

The specific name derives from the type locality, Gunung Jerai. It is also a dedication to the Kedah State Government, the Kedah Forestry Department, and the Malaysian Forestry Department, which are the governing bodies of the Gunung Jerai Forest Reserve and whose kind permission and support made the trip possible.

DISCUSSION

Because members of *Rana* (*Odorrana*) possess distinct digital disks, some of them were once treated as *Hylarana* (e.g. Boulenger, 1920). It was Fei *et al.* (1991) who proposed a distinct genus, *Odorrana*, to encompass *R. livida* and other Chinese relatives. Dubois (1992), however, relegated *Odorrana* as a subgenus of *Rana*, while proposing many other new subgenera, such as *Eburana* and *Chalcorana*, in this genus. He placed *R. narina* and *R. livida* in *Eburana*, and *R. hosii* in *Chalcorana*.

These studies were done exclusively on the basis of morphology, and phylogenetic relationships among the genera treated by Fei *et al.* (1991) and the subgenera treated by Dubois (1992) were poorly known. Recently, Matsui *et al.* (2005) reconstructed the phylogenetic relationships among *Eburana*, *Odorrana*, and *Chalcorana hosii* by an analysis of mitochondrial 12S and 16S rRNA gene sequences, and confirmed the monophyly of these taxa as the subgenus *Odorrana* of the genus *Rana*.

Recent progress in the elucidation of species diversity in *Odorrana* is surely the most splendid among systematic studies of East and Southeast Asian anurans. Many new species have been found, long after the last revisions in these regions (Southeast Asia in general: Bourret, 1942; China: Liu and Hu, 1961; Japan: Nakamura and Uéno, 1963; Thailand: Taylor, 1962; Peninsular Malaysia: Berry, 1975; Borneo: Inger, 1966).

In China, seven species, now assigned to *Odorrana*, were described between 1950 and 1983 (Liu, 1950; Liu and Hu, 1962; Hu *et al.*, 1966, 1973; Yang and Li, 1980; Wu *et al.*, 1983), and five more new species were added in 2001 (Fei and Ye, 2001; Fei *et al.*, 2001a, b). These include several cryptic species once treated as a single species. From

the Ryukyus, Japan, Matsui (1994) described three cryptic species related to *R. narina*, while Bain *et al.* (2003) more recently revised *Odorrana* and clarified the taxonomic status of important species described earlier (*R. livida*, *R. chloronota*, *R. sinica*, *R. leporipes*). They also described six cryptic species allied with *R. chloronota* from Vietnam. Orlov *et al.* (2003) and Bain and Nguyen (2004) each described one new species from Vietnam. Most recently, Stuart and Bain (2005) added three new species allied with *R. megatympanum*, treated as *Odorrana* by Bain *et al.* (2003), from Laos and Vietnam, while relegating one Vietnamese species (*R. tabaca*) as a synonym of another (*R. megatympanum*), both described by Bain *et al.* (2003).

From these recent spectacular discoveries of many cryptic species of *Rana* (*Odorrana*) in Southeast Asian countries, it is not surprising to find one in peninsular Malaysia. *Rana monjerai* would easily have been confused with *R. hosii* or *R. livida* (Taylor, 1962). Indeed, *R. hosii* occurs at higher elevations than does *R. monjerai* on Gunung Jerai. Because the co-occurrence of more than one species of *Odorrana* at a single locality has been reported in Vietnam and Laos (Bain *et al.*, 2003), a similarly syntopic distribution might also be expected on Gunung Jerai. Future intensive field surveys, as well as close examination of many more specimens both morphologically and genetically, will clarify whether this is the case. In conducting such studies, it is important to adequately examine the range of intraspecific variation so as to avoid increasing the number of synonyms.

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